What is Claimed is:

SJ6 Q1

1. A method of constructing a vector space in which a data sample relating to an object may be encoded, comprising: providing a raw matching score between each of a plurality of basis sample elements and each of a plurality of data samples in a first sample database, the samples in the first sample database being out-of-sample with respect to the basis samples; and constructing a sample space from the raw matching scores, the sample space being defined by a basis set of sample space modes.

2. The method of claim 1 wherein constructing the sample space comprises: generating a covariance matrix for the basis elements from the raw matching scores; and determining the eigenvectors and eigenvalues of the covariance matrix, the eigenvectors specifying the sample space modes.

3. The method of claim 2 further comprising: generating a rotation matrix, based on the eigenvectors of the covariance matrix, the rotation matrix mapping raw matching scores into sample space scores.

4. The method of claim 3 further comprising: truncating the sample space by eliminating a subset of the sample space modes, the eliminated modes generally having the lowest eigenvalues.

5. The method of claim 4 wherein truncating the sample space comprises

determining a sample space score between each of a plurality of data samples in a second sample database and each of the sample space modes, the samples in the second sample database being out-of-sample with respect to the basis samples and the samples in the first sample database; and

selecting a cut-off for eliminating a subset of sample space modes based on the distribution of said sample space scores for each of the sample space modes, the distribution being indicative of how well a sample space mode is able to discriminate between samples.

6. The method of claim 5 wherein the sample space scores are normalized with respect to each sample space mode and selecting a cut-off is further based on determining when the distributions of the normalized sample space scores for each sample space mode start to vary by more than an acceptable amount.

7. The method of claim 1 further comprising:

determining a first common object sample space score between each of a plurality of data samples in a first common object sample database and each of the sample space modes;

determining a second common object sample space score between each of a plurality of data samples in a second common object sample database and each of the sample space modes, the first and second common object sample databases each having a set of different samples for the same objects; and

constructing a recognition space from the first common object sample space scores and the second common object sample space scores, the recognition space being defined by a basis set of recognition space modes.

8. The method of claim 7 wherein the sample space scores are normalized with respect to each sample space mode before constructing the recognition space.

9. The method of claim 8 constructing the recognition space comprises: generating a second covariance matrix for the sample space modes from the first common object sample space scores and the second common object sample space scores; and determining the eigenvectors and eigenvalues of the second covariance matrix, the eigenvectors of the second covariance matrix specifying the recognition space modes.

10. The method of claim 9 further comprising: generating a second rotation matrix, based on the eigenvectors of the second covariance matrix, the second rotation matrix mapping sample space scores into recognition space scores.

11. The method of claim 10 further comprising: truncating the recognition space by eliminating a subset of the recognition space modes, the eliminated recognition space modes generally having the highest eigenvalues of the second covariance matrix.

12. The method of claim 11 wherein truncating the recognition space comprises

determining a recognition space score between each of a plurality of data samples in a third sample database and each of the recognition space modes, the samples in the third sample database being of objects not sampled in the basis samples, the samples in the first sample database, the samples in the first common object database, or the samples in the second common object database; and

selecting a cut-off for eliminating a subset of recognition space modes based on the distribution of said recognition space scores for each of the recognition space modes, the distribution being indicative of whether a recognition mode is generally unsuitable for recognizing different samples of the same object.

13. The method of claim 12 wherein selecting a cut-off is further based on determining when the distributions of the recognition space scores for each sample space mode start to vary by more than an acceptable amount.

14. The method of claim 7 further comprising: before constructing the recognition space, truncating the sample space by eliminating a subset of the sample space modes; and truncating the recognition space by eliminating a subset of the recognition space modes.

15. The method of claim 7 wherein the recognition space is constructed using linear discriminant analysis.

16. The method of claim 7 wherein the recognition space is constructed using non-linear discriminant analysis.

17. The method of claim 7 further comprising selecting the plurality of basis sample elements at random.

18. The method of claim 1 further comprising selecting the plurality of basis sample elements at random.

19. A method of encoding a data sample relating to an object to enable the object to recognized, comprising:

constructing a sample space using the method of claim 1;

providing a raw matching score between said data sample and each of the plurality of basis sample elements; and

mapping the raw matching scores of said data sample into sample space scores.

20. A method of recognizing whether a probe data sample matches one of a plurality of known data samples comprising:

encoding the known data samples using the method of claim 19, and storing the results in a reference database;

encoding the probe data sample using the method of claim 19;

measuring the distance between the sample space scores for the probe sample and each known sample in the sample space; and

determining which encoded known sample is nearest to the encoded probe sample in the sample space.

21. A method of encoding a data sample relating to an object to enable the object to recognized, comprising:

constructing a truncated sample space using the method of claim 4;

providing a raw matching score between said data sample and each of the plurality of basis sample elements; and

mapping the raw matching scores of said data sample into truncated sample space scores.

22. A method of recognizing whether a probe data sample matches one of a plurality of known data samples comprising:

encoding the known data samples using the method of claim 21, and storing the results in a reference database;

encoding the probe data sample using the method of claim 21;

measuring the distance between the truncated sample space scores for the probe sample and each known sample in the truncated sample space; and

determining which encoded known sample is nearest to the encoded probe sample in the truncated sample space.

23. A method of encoding a data sample relating to an object to enable the object to recognized, comprising:

constructing a recognition space using the method of claim 7;

providing a raw matching score between said data sample and each of the plurality of basis sample elements;

mapping the raw matching scores of said data sample into sample space scores; and

mapping the sample space scores of said data sample into recognition space scores.

24. A method of recognizing whether a probe data sample matches one of a plurality of known data samples comprising:

encoding the known data samples using the method of claim 23, and storing the results in a reference database;

encoding the probe data sample using the method of claim 23;

measuring the distance between the recognition space scores for the probe sample and each known sample in the recognition space; and

determining which encoded known sample is nearest to the encoded probe sample in the recognition space.

25. A method of encoding a data sample relating to an object to enable the object to recognized, comprising:

constructing a recognition space using the method of claim 14;

providing a raw matching score between said data sample and each of the plurality of basis sample elements;

mapping the raw matching scores of said data sample into truncated sample space scores; and

mapping the sample space scores of said data sample into truncated recognition space scores.

26. A method of recognizing whether a probe data sample matches one of a plurality of known data samples comprising:

encoding the known data samples using the method of claim 25, and storing the results in a reference database;

encoding the probe data sample using the method of claim 25;

measuring the distance between the truncated recognition space scores for the probe sample and each known sample in the truncated recognition space; and

determining which encoded known sample is nearest to the encoded probe sample in the truncated recognition space.

27. The method of claim 24 wherein the objects are persons, the data samples represent faces of the persons, and the method is used to perform face recognition.

28. The method of claim 26 wherein the objects are persons, the data samples represent fingerprints of the persons, and the method is used to perform fingerprint recognition.

29. The method of claim 24 wherein the objects are persons, the data samples are face templates, and the method is used to perform face recognition.

30. The method of claim 26 wherein the objects are persons, the data samples represent fingerprints of the persons, and the method is used to perform fingerprint recognition.

31. For use in object recognition, a space construction and encoding system comprising: a sample space construction module for receiving a data sample relating to an object to be encoded, a plurality of basis sample elements, and plurality of data samples in a first sample database, the samples in the first sample database being out-of-sample with respect to the basis samples; the sample space construction module providing a raw matching score between each basis element and each of the plurality of data samples in the first sample database, and constructing a sample space from the raw matching scores, the sample space being defined by a basis set of sample space modes.

32. The system of claim 31 wherein the sample space construction module generates a covariance matrix for the basis elements from the raw matching scores, and determines the eigenvectors and eigenvalues of the covariance matrix, the eigenvectors specifying the sample space modes.

33. The system of claim 32 wherein the sample space construction module further generates a rotation matrix, based on the eigenvectors of the covariance matrix, the rotation matrix mapping raw matching scores into sample space scores.

34. The system of claim 33 further comprising a sample space truncation module for truncating the sample space by eliminating a subset of the sample space modes, the eliminated modes generally having the lowest eigenvalues.

35. The system of claim 31 further comprising a recognition space construction module for receiving a plurality of data samples in a first common object sample database and plurality of data samples in a second common object sample database, the first and second common object sample databases each having a set of different samples for the same objects; wherein the recognition space construction module determines a first common object sample space score between each of the plurality of data samples in the first common object sample database and each of the sample space modes and further determines a second common object sample space

score between each of the plurality of data samples in the second common object sample database and each of the sample space modes, the recognition space construction module constructing a recognition space from the first common object sample space scores and the second common object sample space scores, the recognition space being defined by a basis set of recognition space modes.

36. The system of claim 35 wherein the sample space scores are normalized with respect to each sample space mode before construction the recognition space.

37. The system of claim 36 wherein the recognition space construction module generates a second covariance matrix for the sample space modes from the first common object sample space scores and the second common object sample space scores, the recognition space construction module further determining the eigenvectors and eigenvalues of the second covariance matrix, the eigenvectors of the second covariance matrix specifying the recognition space modes.

38. The system of claim 37 wherein the recognition space construction module further generates a second rotation matrix, based on the eigenvectors of the second covariance matrix, the second rotation matrix mapping sample space scores into recognition space scores.

39. The system of claim 38 further comprising a recognition space truncation module for truncating the recognition space by eliminating a subset of the recognition space modes, the eliminated recognition space modes generally having the highest eigenvalues of the second covariance matrix.

40. The system of claim 35 further comprising: a sample space truncation module for truncating the sample space by eliminating a subset of the sample space modes; and a recognition space truncation module truncating the recognition space by eliminating a subset of the recognition space modes.

41. The system of claim 35 wherein the recognition space construction module uses linear discriminant analysis in constructing the recognition space.

42. The system of claim 35 wherein the recognition space construction module uses non-linear discriminant analysis. in constructing the recognition space.

43. The system of claim 35 wherein the plurality of basis sample elements are selected at random.

44. The system of claim 31 wherein the plurality of basis sample elements are selected at random.

45. The system of claim 35 wherein the objects are persons, the data samples represent faces of the persons, and the system is used to perform face recognition

46. The system of claim 35 wherein the objects are persons, the data samples represent fingerprints of the persons, and the system is used to perform fingerprint recognition.

47. The system of claim 31 wherein the objects are persons, the data samples represent faces of the persons, and the system is used to perform face recognition

48. The system of claim 31 wherein the objects are persons, the data samples represent fingerprints of the persons, and the system is used to perform fingerprint recognition.